Effects of Real-Time Vegetation Data on Model Forecasts of Severe Weather

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92nd annual AMS meeting

16th Symp. on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (16 IOAS-AOLS)

Talk #15.4, 26 January 2012

Objectives of Experiment

- Assess impacts of high-resolution, real-time vegetation data on model forecasts of severe weather
  - Document model sensitivity to real-time versus climatological greenness vegetation fraction (GVF)
  - Can incorporating real-time GVF improve simulations of severe weather events?
- Employ unique NASA assets in modeling study
  - NASA-Unified Weather Research and Forecasting (NU-WRF)
  - Combination of several NASA capabilities into a single modeling software package

Default GVF Dataset in WRF Model

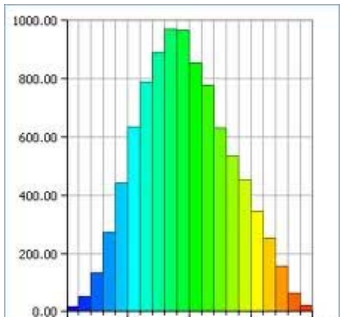
- Five-Year Monthly Global Climatology
  - Derived from AVHRR Normalized Difference Vegetation Index (NDVI) data from 1985–1991
  - 0.144° resolution, valid at mid-point of each month
  - Currently in Noah LSM within NCEP/NAM and WRF models

- Cannot account for variations in GVF due to:
  - Weather/climate anomalies (e.g. drought, excessive rain)
  - Land-use changes since the early 1990s (e.g. urban sprawl)
  - Wildfires and prescribed burn regions

SPoRT Daily Real-Time Vegetation Product

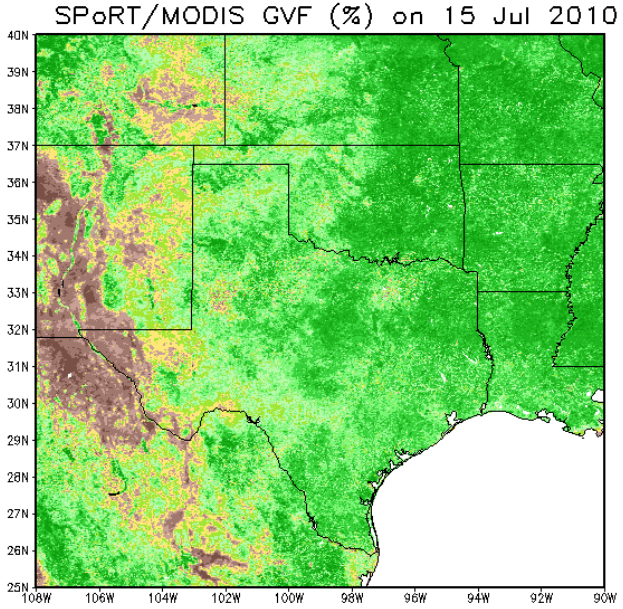
- Continental-U.S. NDVI/GVF grid at 0.01° resolution
  - NDVI from real-time MODIS swaths, mapped to CONUS grid
  - Time-weighted NDVI composites produced from up to 6 NDVI values in the previous 20 days
  - Daily composites generated since 1 June 2010
  - Calculate GVF on 0.01° grid for use in LIS/Noah LSM
    - Create distributions of $NDVI_{max}$ as a function of land use
    - Obtain 90th percentile $NDVI_{max}$ for each land class ($NDVI_{max,i}$)
    - Obtain 5th percentile $NDVI_{max}$ for barren land use ($NDVI_{min}$)
    - Calculate GVF using the following formula:

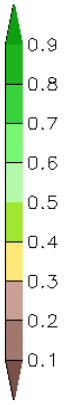
$$GVF_i = \frac{NDVI_i - NDVI_{min}}{NDVI_{max,i} - NDVI_{min}}$$

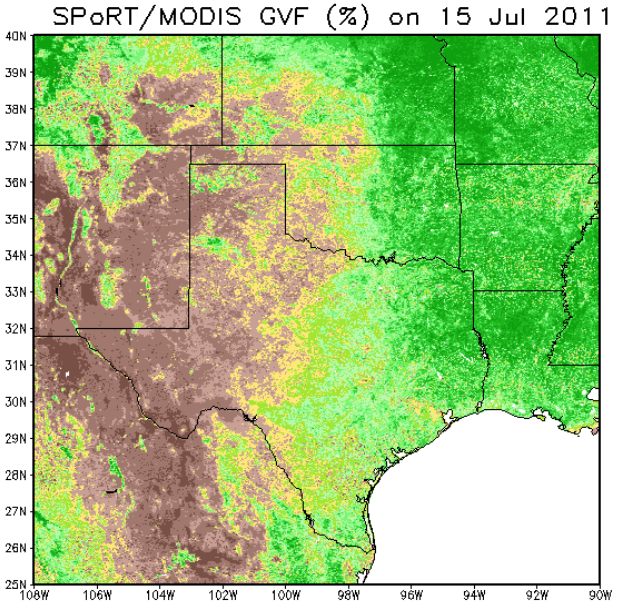


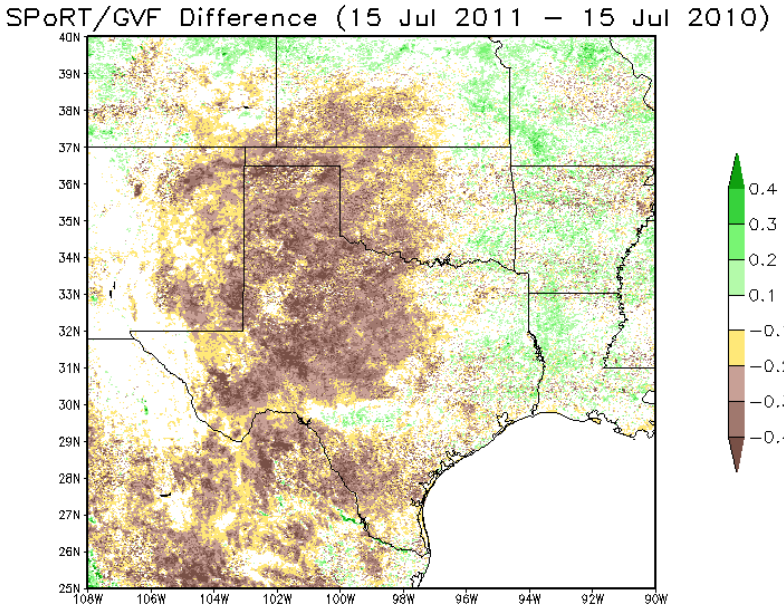
$NDVI_{min}$ $NDVI_{max,i}$

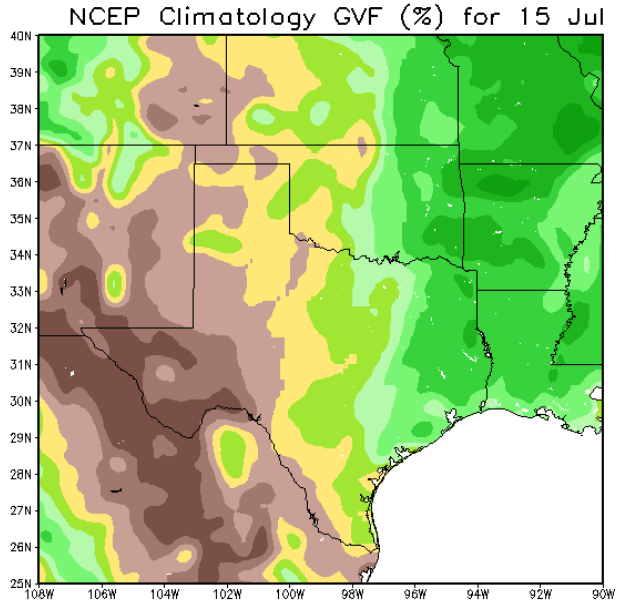
GVF 1-year Diff on 15 July: 2010 to 2011











Big 1-yr diff in GVF

- TX was very wet in early summer 2010
- Virtually no rain in TX/OK in 2011
- 1-yr reduction in GVF, up to 40%+
- Shows how much GVF can change from year to year
- Climo doesn't cut it!

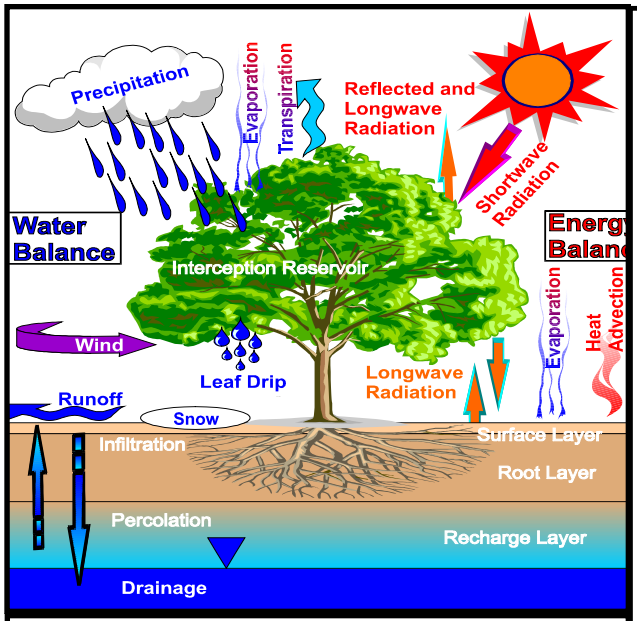
2011 MODIS GVF actually compares better to NCEP climo

- Texas summers should be dry!

Platform: NASA Unified-WRF (NU-WRF) model

- Based on Advanced Research WRF dynamical core
- Incorporates numerous capabilities & NASA assets
  - Physics schemes (Goddard radiation, microphysics)
  - Goddard satellite data simulator unit
  - Land Information System (LIS) and LIS Verification Toolkit
  - Goddard Chemistry Aerosol Radiation and Transport (GOCART)
  - Model verification and numerous post-processing options
  - Coupling between WRF model and LIS/GOCART

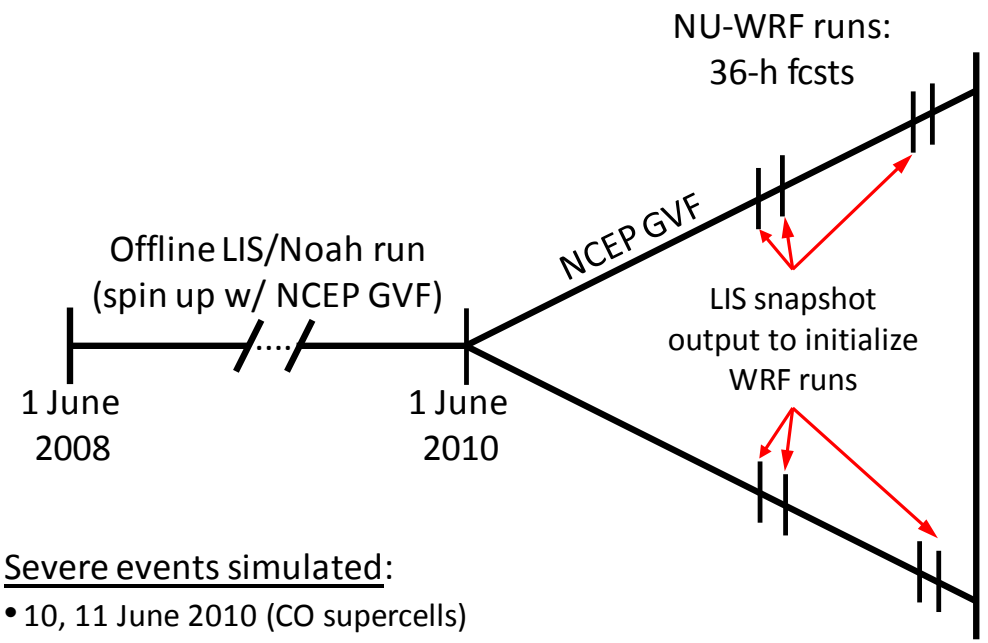
Approach and Methods



Offline LIS run:

→Noah Land Surface Model

→Atmospheric analyses from GFS Data Assim. System



Severe events simulated:

- 10, 11 June 2010 (CO supercells)
- 15 June 2010 (SE U.S. convective winds)
- 17 July 2010 (Upper Midwest tornadoes/wind)
- 27 April 2011 (Super tornado outbreak)
- 22 May 2011 (Joplin, MO EF-5)
- 24-25 May 2011 (OK/MS Valley tornadoes/severe)

Same WRF model configuration/physics as 4-km NSSL CONUS real-time runs:
http://www.nssl.noaa.gov/wrf/

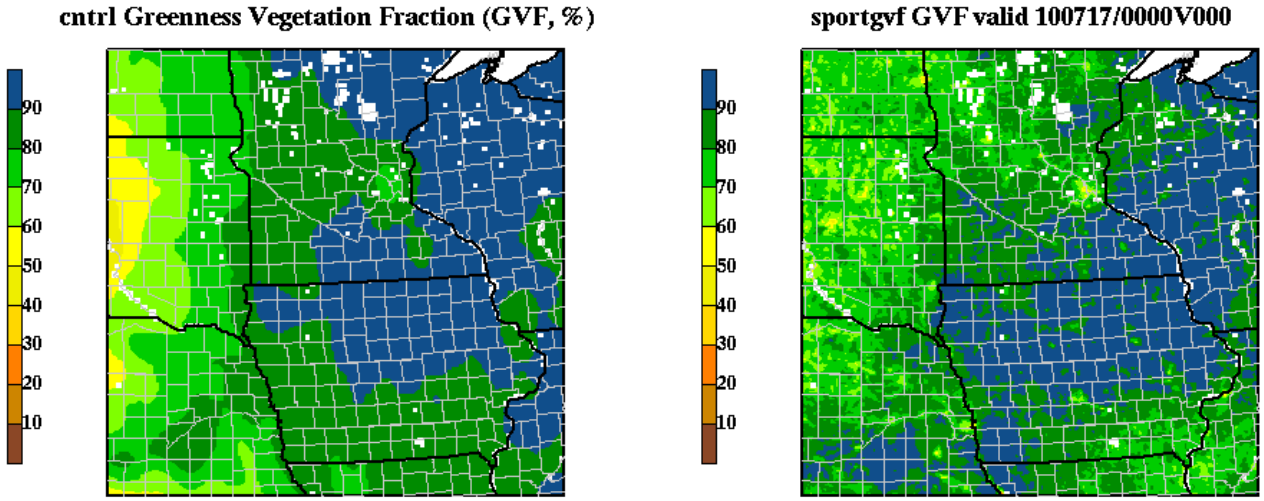
Results: General Observations

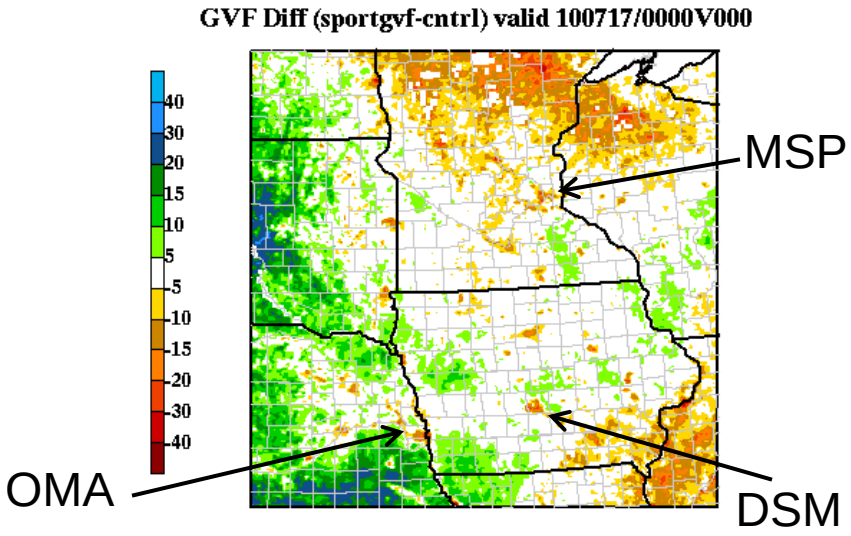
- Substantial changes to sensible/latent heat fluxes, and 2-m temperatures/dewpoints in places

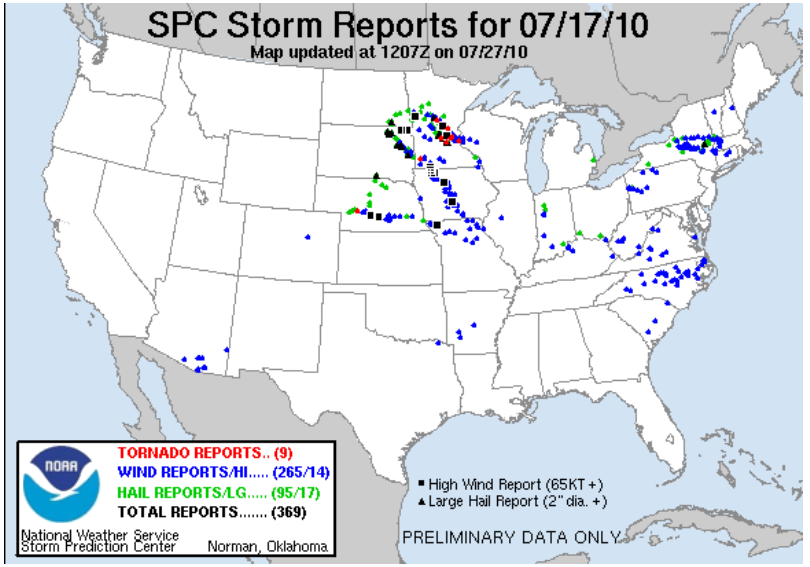
- However, most simulations look fairly similar to each other
  - Similar model errors in onset/timing of convection
  - Good/Poor control simulations ↔ good/poor experimental forecasts

- Greatest differences occur with maximum surface heating
  - 17 July 2010: Good case with convection firing late in day
  - 22 May 2011: Notable differences on Joplin, MO tornado day

17 July 2010 WRF Case Study

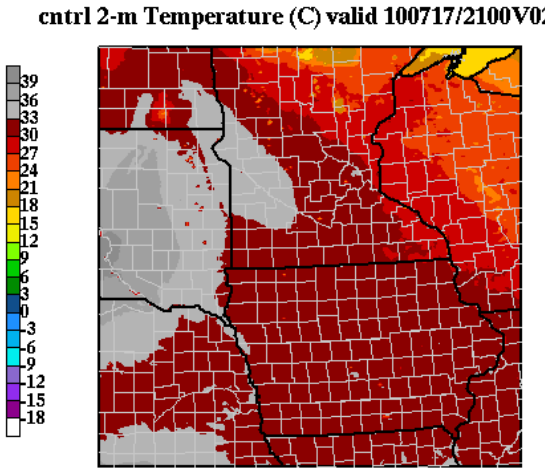


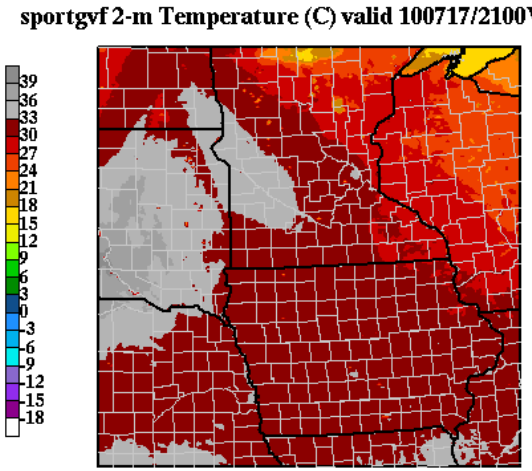


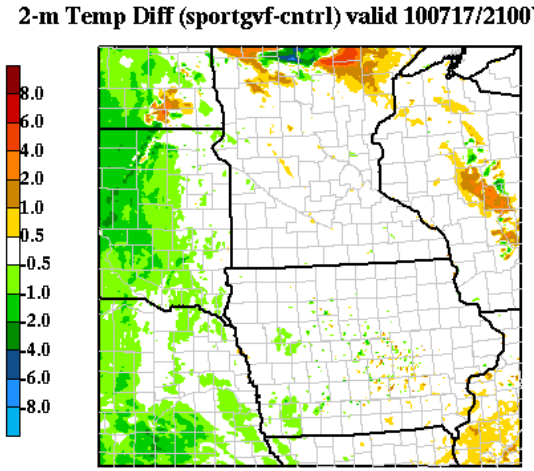


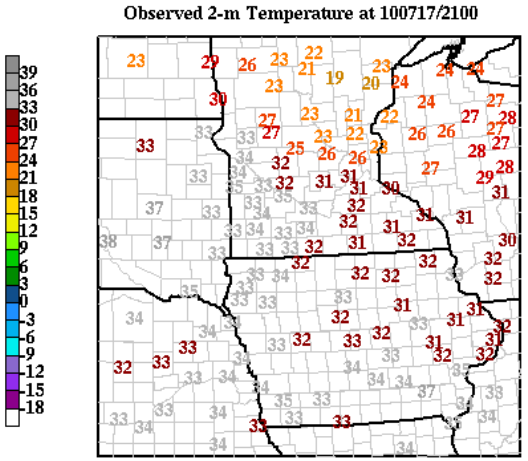
- Urban areas can be resolved much better by the SPoRT GVF.
- Higher GVFs prevail from NE to ND.

17 Jul 2010, WRF 21-h fcst: 2-m Temp





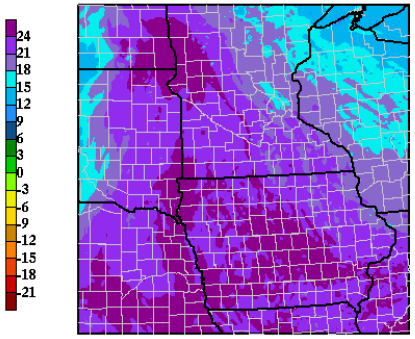




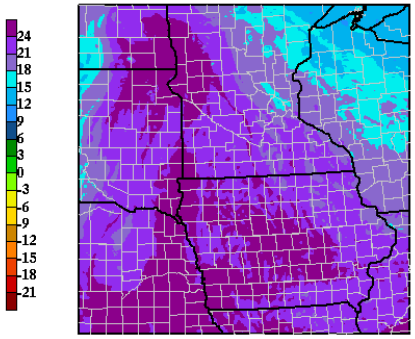
Higher SPoRT GVFs in the western portion of the focus area correctly led to lower forecast 2-m temperatures

17 July 2010, WRF 21-h fcst: 2-m Dewp/CAPE

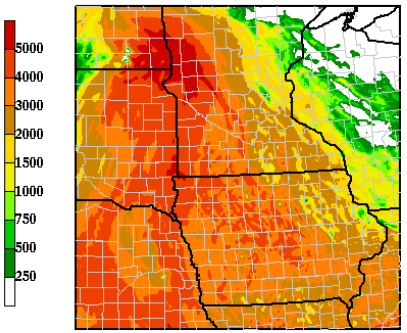
cntrl 2-m Dewpoints (C) valid 100717/2100V021



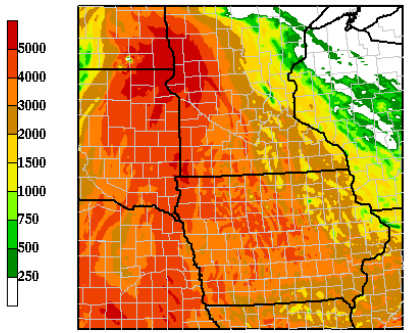
sportgvf 2-m Dewpoints (C) valid 100717/2100V021



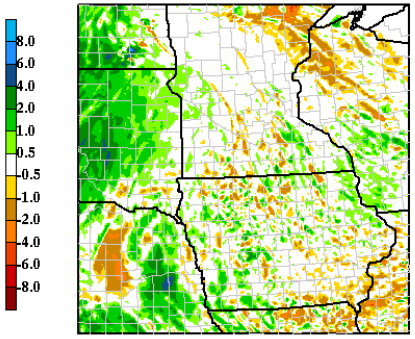
cntrl CAPE (J/kg) valid 100717/2100V021



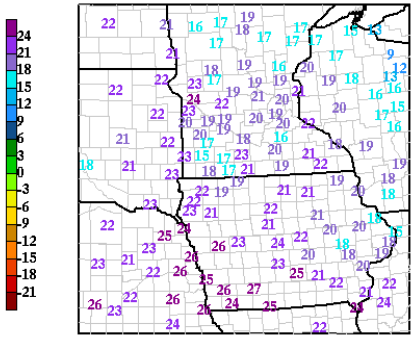
sportgvf CAPE (J/kg) valid 100717/2100V021



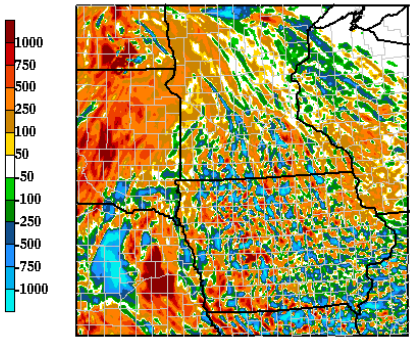
2-m Dewp Diff (sportgvf-cntrl) valid 100717/2100V021



Observed 2-m Dewpoint at 100717/2100

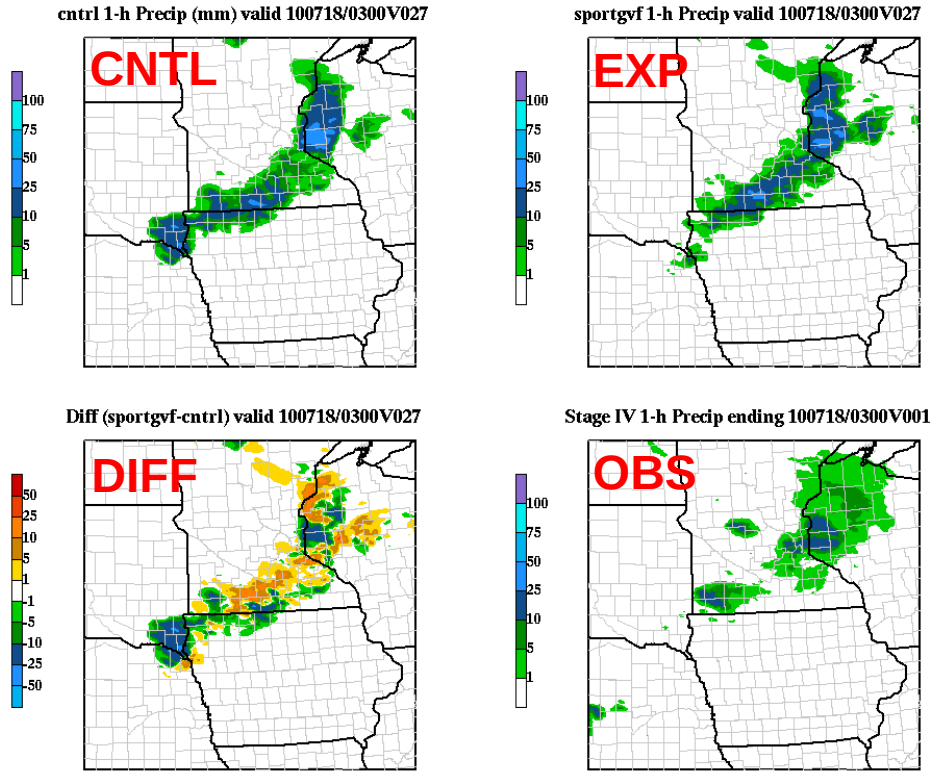


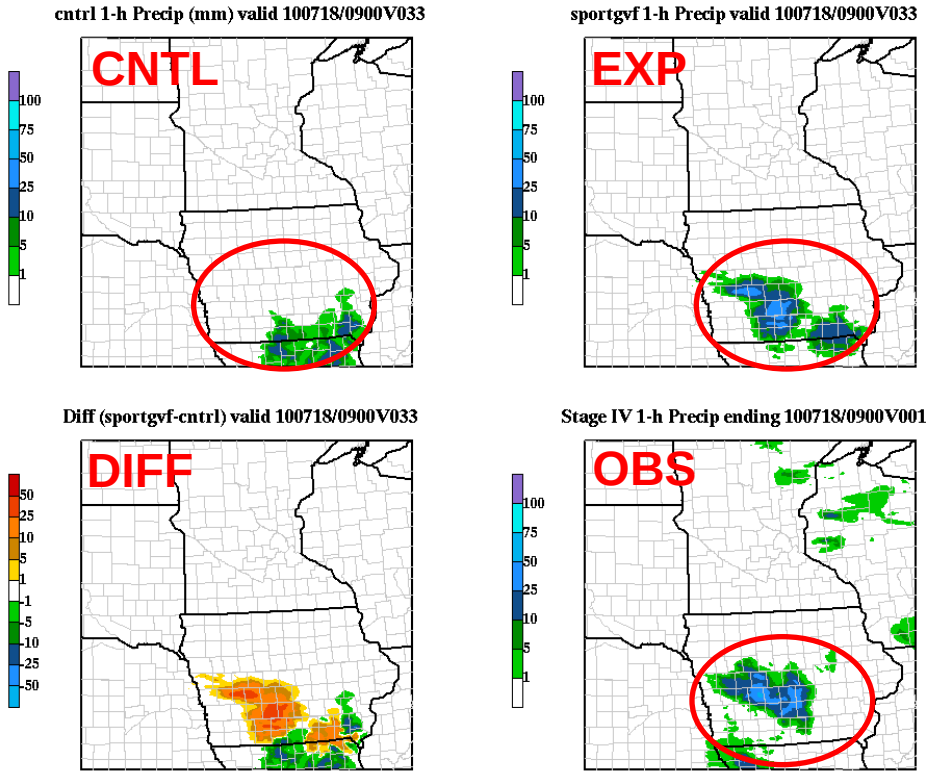
CAPE Diff (sportgvf-cntrl) valid 100717/2100V021



- Higher GVF values lead to higher 2-m dewpoints
- Net result is increase in CAPE up to 1000 J kg^{-1}

17 July 2010, WRF Fcst 1-h precip: 27/33 h

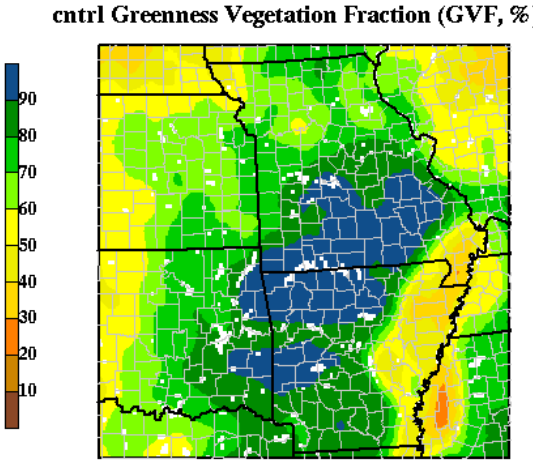


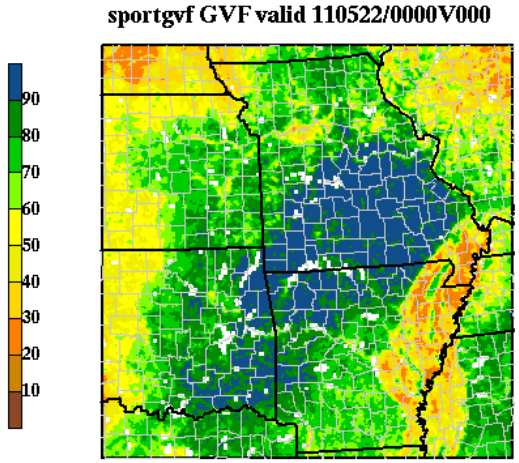


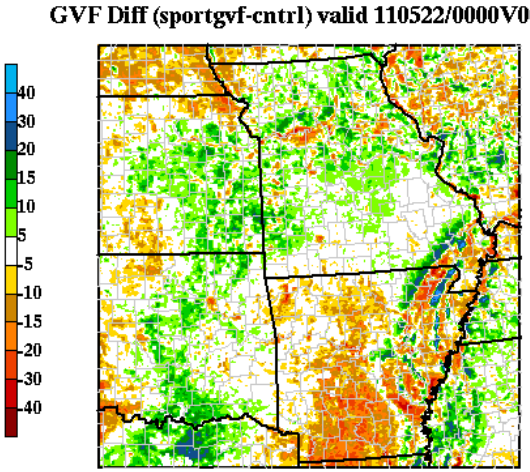
- Both model runs close on placement with initial development and movement
- Some intensity variations

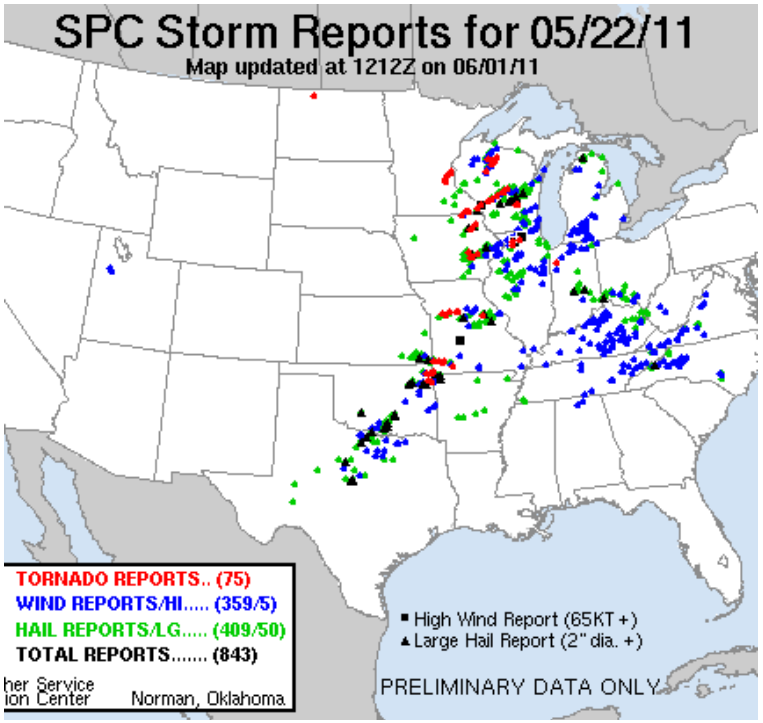
- cntrl run moves convection southward through Iowa too quickly
- sportgvf run correctly re-develops convection along IA/NE border and has slower evolution in Iowa

22 May 2011: Joplin, MO tornado day

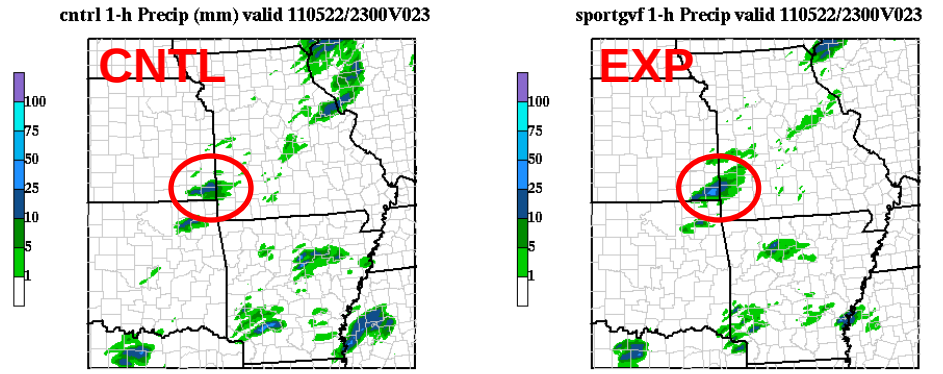


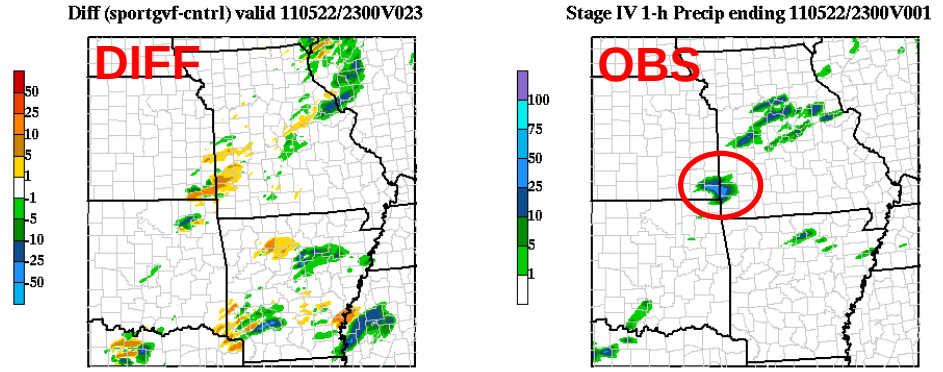




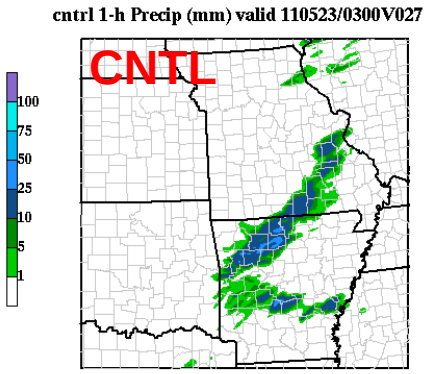


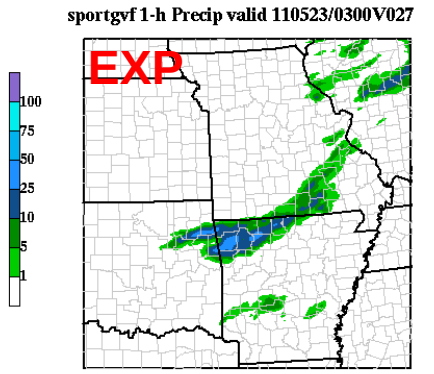
22 May 2011, WRF fcst 1-h precip: 23/27 h

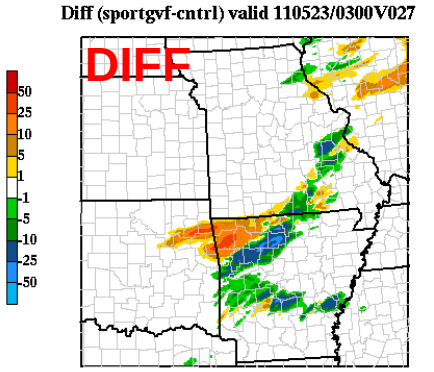


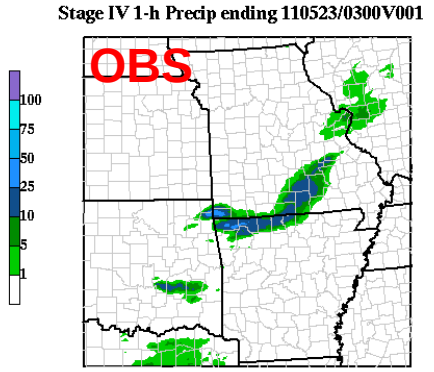


- More intense 1-h rain rates in sportgvf run just prior to tornadic event
- Both runs have too much false alarm in AR









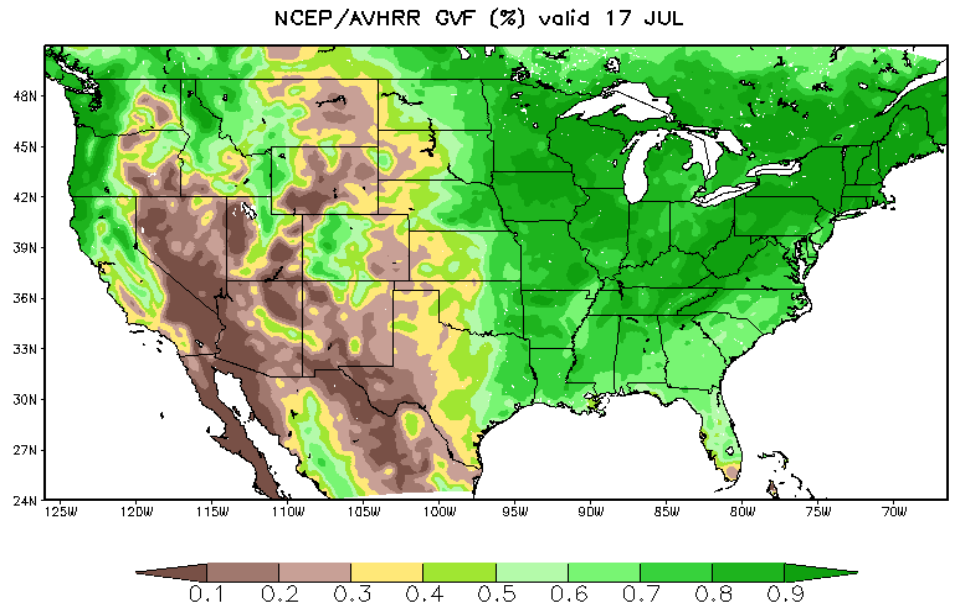
- After event, sportgvf run better handles squall line evolution into Arkansas
- Reduced false alarm in central Arkansas

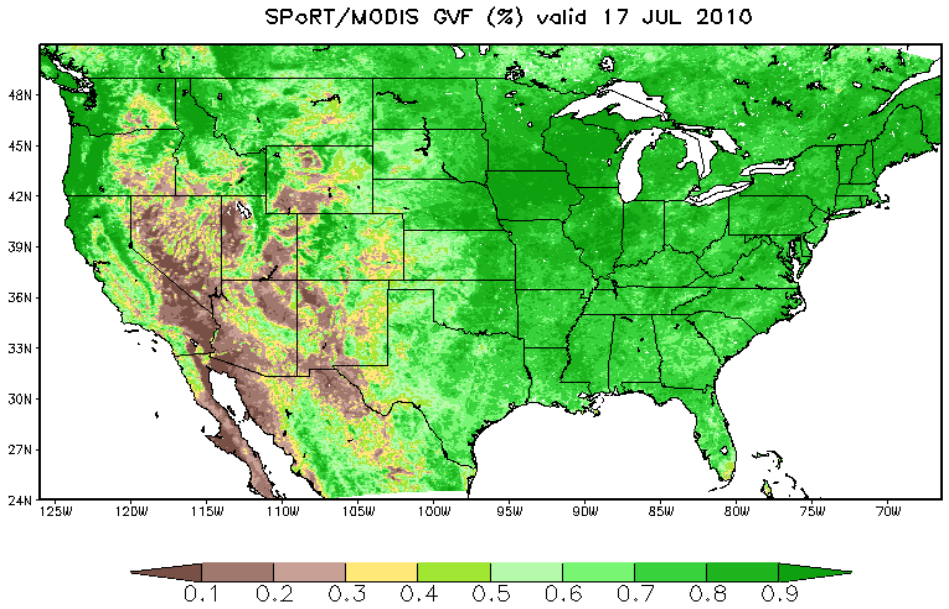
Summary and Future Work

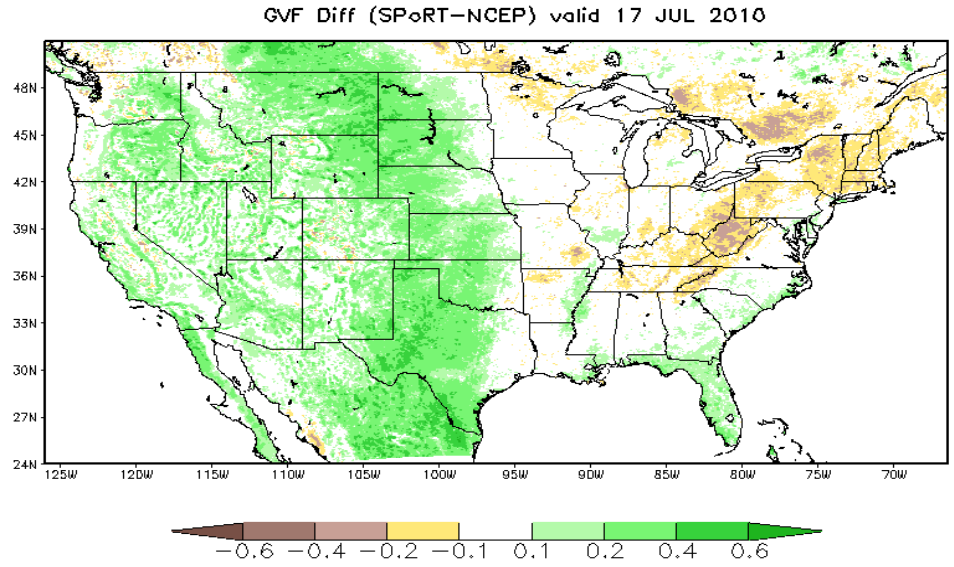
- SPoRT developed CONUS 1-km GVF dataset (1 June 2010 to date)
- Using SPoRT GVFs in a couple cases showed some improvement over control
- Real-time vegetation data have potential to increase accuracy of models in severe weather events
- Future work
  - Continue analyzing cases; generate verification stats
  - Examine impacts of real-time GVFs during 2011 Texas drought
  - Incorporate real-time albedo information

Backup Slides

GVF Comparison: 17 July 2010

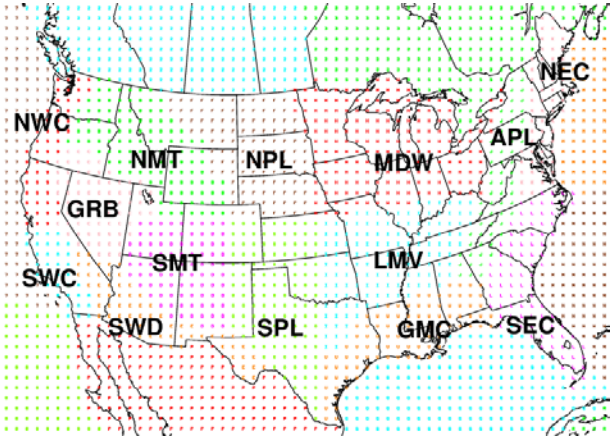




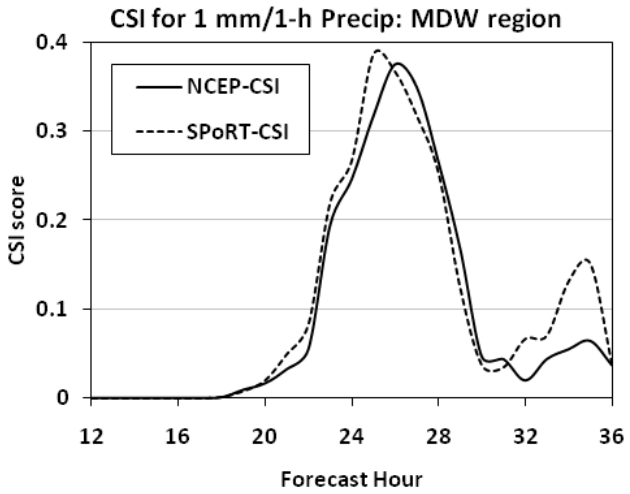


- Improved resolution
  - Ability to resolve vegetation variation in complex terrain
- Greener in Western U.S.
  - Nearly 20-40% over High Plains
  - High Plains rainfall well above average in previous 3 months

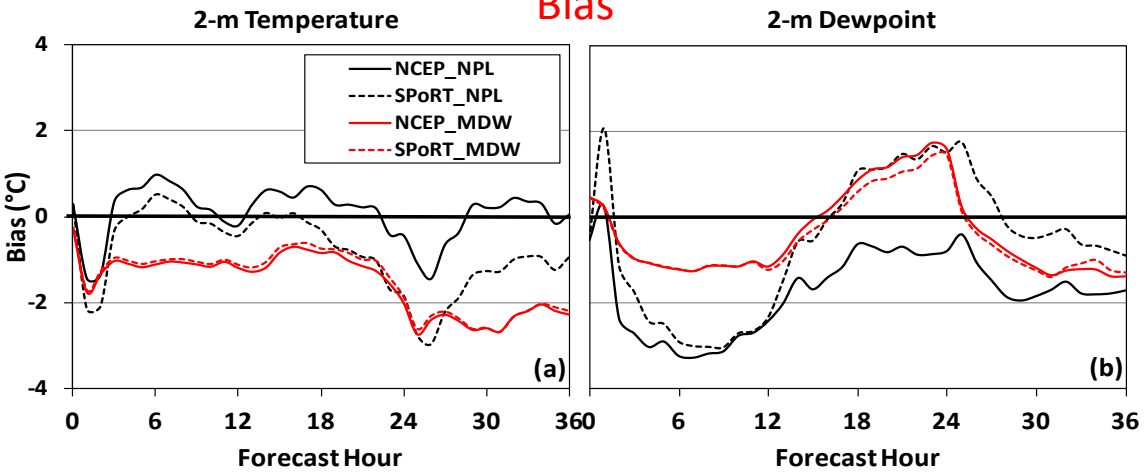
17 July 2010: Verification Stats



Verification Stats: Critical Success Index



Bias



Error Standard Deviation